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LOCALISED TREATMENT AND REUSE OF WASTEWATER: SCIENCE, TECHNOLOGY AND MANAGEMENT

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INTRODUCTION

The primary objective of wastewater treatment and disposal is the protection of public health. Wastewater of domestic origin contains pathogens, suspended solids (SS), substances causing biochemical oxygen demand (BOD), nutrients (nitrogen (N) and phosphorus (P)) and a hosts of other possible pollutants, which may need to be removed before the wastewater can be safely disposed. Standards have been developed for the safe disposal of the wastewater, and so have the technologies to meet them. The technologies that have been developed are generally for centralised large scale systems associated with reticulated sewerage, and the treated wastewater is for disposal rather than reuse. Options for reuse are recognised as being limited with large scale systems in urban areas, because of the need of a reticulation system for the treated wastewater.

On-site treatment of wastewater for individual houses is a necessity in areas without reticulated sewerage, but interest in on-site treatment is growing. One reason is that the technology for on-site treatment is maturing, and reuse of the treated wastewater is an option. Thus the owner of an on-site system has total control of the wastewater and its use. In an urban community where there is a desire to develop an urban village the treatment of wastewater from a group of houses within the urban village community offers the opportunity to achieve what is desired by such communities, i.e. integrated management of water.

The maturing of the technology for on-site wastewater treatment is due to a large part to the application of scientific principles to the improvement of the outdated septic tank technology. This paper therefore broadly reviews the scientific principles applicable to on-site wastewater treatment and reuse, and assesses available technologies with respect to their science content.

On-site treatment of wastewater may not provide all the answers to the problems of wastewater disposal and reuse. Issues needing to be addressed are, for example, whether individual householders can be expected to maintain a sophisticated wastewater treatment unit in the backyard, and the imbalance between water supply and demand in different seasons. This paper therefore also attempts to discuss issues related to the management of on-site wastewater treatment units, and whether science and technology can provide answers. An introductory paper like this one can only attempt to cover some of the issues and stimulate discussions in subsequent sessions in the workshop.

SCIENTIFIC PRINCIPLES

The physical, chemical and biological bases for the treatment of wastewater to remove BOD, SS, N, P and pathogens are well established. They have been studied as part of efforts to improve the technologies for large scale wastewater treatment systems. These are shown in Table 1. They should obviously be applicable to small scale and on-site treatment systems.

TABLE 1 PHYSICAL, CHEMICAL AND BIOLOGICAL BASES FOR WASTEWATER TREATMENT

SCIENTIFIC BASES	EXAMPLES OF PHYSICAL OPERATIONS OR CHEMICAL/BIOLOGICAL PROCESSES
PHYSICAL PRINCIPLES	Screening Sedimentation Sand Filtration Aeration Adsorption (Activated Carbon) Membrane filtration
BIOLOGICAL PRINCIPLES	Removal of BOD: Use of aerobic bacteria Use of anaerobic bacteria Removal of N: Nitrification Denitrification Removal of P: Luxury uptake
CHEMICAL PRINCIPLES	Coagulation & flocculation Precipitation Chlorination

An example of an application to large scale systems is the conventional primary and secondary treatment utilising an activated sludge plant. Here raw wastewater is screened to remove large objects, then grits are removed in an aerated sedimentation tank, followed by sedimentation of the smaller suspended solids, producing a primary effluent. Further treatment by aerated microorganisms removes BOD, and sedimentation clarifies the secondary effluent, returning the microorganisms (activated sludge) to the aeration tank. Secondary effluent containing less than 20 mg/L BOD and 30 mg/L SS can be achieved without difficulty. The 20 mg/L BOD and 30 mg/L SS standard was, in fact, based on what could be achieved by primary and secondary treatment of sewage. Disposal to rivers or reuse for irrigation of recreational parks is generally permitted after chlorination to reduce the concentration of pathogens.

It has become more necessary now to remove N and P prior to disposal to rivers or onto land, because of the need to prevent eutrophication of surface waters.

Ammonium-N in secondary effluent can be removed as ammonia by liming and aeration. Nitrogen can also be removed by biological nitrification and denitrification. Similarly P can be removed by chemical precipitation using lime or alum or a ferric salt, or removed biologically.

Sludge from the primary and secondary treatment also needs to be treated prior to disposal or reuse. Again physical, chemical and biological means are available (Table 2).

TABLE 2 PHYSICAL, CHEMICAL AND BIOLOGICAL BASES FOR TREATMENT OF SLUDGE

SCIENTIFIC BASES	EXAMPLES OF PHYSICAL OPERATIONS OR CHEMICAL/BIOLOGICAL PROCESSES
PHYSICAL PRINCIPLES	Thickening Vacuum Filtration
BIOLOGICAL PRINCIPLES	Anaerobic digestion Composting
CHEMICAL PRINCIPLES	Coagualtion and flocculation Incineration

Needless to say, understanding the physical, chemical and biological bases of wastewater treatment enables us to develop an innovative treatment system to achieve any particular objective or standard by combining physical/ chemical/ biological units. Innovative treatment systems include combined BOD and N removal in a series of anaerobic and aerobic chambers, or alternate aeration and non aeration of one chamber.

Following secondary treatment and removal of nutrients by liming, recharge of groundwater is possible after coagulation, flocculation, sedimentation. sand filtration (i.e. a rapid sand filter) and chlorination; and even to produce potable water with further activated carbon adsorption and membrane filtration treatment.

ON-SITE TREATMENT TECHNOLOGY

Current on-site treatment sytems have generally adopted the technology of the conventional activated sludge plant for large treatment systems. This is understandable, because the effluent standard for reuse for garden irrigation is a chlorinated effluent containing not more than 20 mg/L BOD and 30 mg/L SS, i.e. secondary effluent that can be achieved without difficulty using an activated sludge process. Differences that can be observed are the insertion of a trickling filter in the aeration chamber to cope with variable flows and the infrequent removal of sludge. Thus anaerobic decompostion of sludge takes place in the first settling chamber. It appears that current commercially available on-site treatment units would benefit from a thorough scientific scrutiny of the operation of their components to optimise overall performance.

If removal of nutrients are required for installation of on-site units in nutrient sensitive catchments, P can be removed by alum dosing, and N by nitrification and denitrification in separate chambers or by intermittent aeration of a modified activated sludge set-up. Hyperchlorination of ammonium in secondary effluent theoretically removes N by oxidation to nitrogen gas.

If the effluent is used for irrigation of garden plants, there is the question as to why N and P, which are required by plants, should be removed. There may be an imbalance between plant requirement for the nutrients and the seasons, with a high requirement in the warmer months than in the colder months. Rather than removing the nutrients, an alternative is to store the nutrients in the soil. Soils containing clay have the capacity to sorp ammonium and phosphate present in secondary effluent. Sandy soils deficient of clay minerals can be amended with clay (or near an alumina refinery, use red mud, residue from the processing of bauxite into alumina).

Effluent stream segregation is a recognised method for the treatment of industrial wastewaters, where low volume high strength wastes are segregated from high volume low strength wastes. Treatment of the former can be more effectively carried out in a smaller system, while the latter may not need treatment or little treatment. This situation presents itself when we consider on-site treatment of domestic wastewater, where we hava a low volume high strength waste from the toilets (commonly called black water) and a high volume low strength waste from the rest (bathroom, laundry, kitchen), commonly called grey water. Development of on-site systems taking advantage of this should be encouraged. We are now beginning to see dry/ composting toilets, and proposals for the reuse of grey water.

MANAGEMENT OF ON-SITE UNITS

Management issues which need to be discussed are public health, maintenance of an on-site unit and rating.

Public health (including the health of owners) is guarded through standard for the reuse of the treated effluent. This standard is well defined now in terms of the number of coliform organisms which should not be exceeded in the effluent. This is turn is related to the degree of tretment (secondary effluent standard) and chlorination with a minimum chlorine residue. If a unit is properly operated the effluent standard should be achieved. Thus the issue is closely related to the next, i.e. of maintenance.

Can a lay householder be expected to maintain a sophisticated on-site unit? The answer to this question is dependent on a number of factors. Robustnes of the technology is a key factor. On-site units are now designed with reliability as good as modern household appliances (e.g. refridgerators) and can be regarded as such. Regular maintenance is required, e.g. sludge removal. Ideally a regular, say three monthly, maintenance contract should be an available option with the supplier of an installed on-site unit. The cost affordability of this option is dependent on whether a property is in a reticulated sewerage area and hence rated, i.e. whether connected to the sewer or not.

Since on-site units are designed for non-sewerage reticulated area, the question on rating only arises when sewerage reticulation comes to an area where an on-site unit has been installed. Should a property previously not on reticulated sewerage be rated when reticulated sewerage is available, even though the property has a sophisticated on-site treatment unit? This question will become more relevant when the concept of integrated management of water is adopted in an urban community wishing to develop an urban village.